

# An attempt to reduce impacts of limestone quarries through biodiversity assessment and translocation: A case study at the Holcim Limestone Quarry Site in Puttalam, Sri Lanka

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## ABSTRACT

A conservation project was implemented at a commercial limestone quarry site in Sri Lanka managed by Holcim Lanka (Pvt.) Ltd. The project intended to assess the biodiversity of a proposed excavation site and to translocate fauna that will be affected by quarry operations such as forest clearance and blasting. The biodiversity of the area was surveyed using a rapid assessment technique, prior to the initiation of forest clearance and blasting. A total of 41 floral species and 220 faunal species were recorded from the project site. Around 90 % of the fauna were amphibians, reptiles and butterflies. Among these species, one endemic tree, a therapsid spider and 20 endemic vertebrates. Among the vertebrates documented, 9 species are categorized as nationally threatened. A total of 141 vertebrates and 85 arthropods and mollusks including endemics threatened species were captured and translocated to Sethtavilluwa area. This project is the first ever initiative in Sri Lanka aimed at reducing impacts of quarry operation on biota through rehabilitation and rescue operations. Such projects are invaluable as they will, at least in part assist in safeguarding biota that will be vulnerable to local extinction as a result of developmental projects.

**Key words:** Conservation, Dry zone, Extinction, Miocene-bets, Rescue mission, Threatened

## INTRODUCTION

Many species of animals and plants are disappearing at an unprecedented rate due to the direct or indirect effects of anthropogenic activities (Achard *et al.*, 2002; Alford *et al.*, 2007). The inevitable destruction and degradation of natural habitats caused by developmental activities result in local extinction, range reductions or population declines of many species. Like elsewhere in the world, the expansion of the human population in Sri Lanka is taking a heavy toll on its natural ecosystems. In fact the Southwest Sri Lanka together with the Western Ghats of India is said to support the highest human population density among the world's biodiversity hotspots (Bossuyt *et al.*, 2004; Cincotta *et al.*, 2000; Helgen and Groves, 2005). Not surprisingly, some of the island's plants and animals have already become extinct whilst many others face threats of near extinction (IUCN-SL and MENR-SL, 2007).

The unavoidable expansion of human population in the future will inevitably result in more development, in turn resulting in further loss and degradation of natural habitats taking with them their inhabitant species. While development is essential for any developing country such as Sri Lanka, it is indeed necessary for

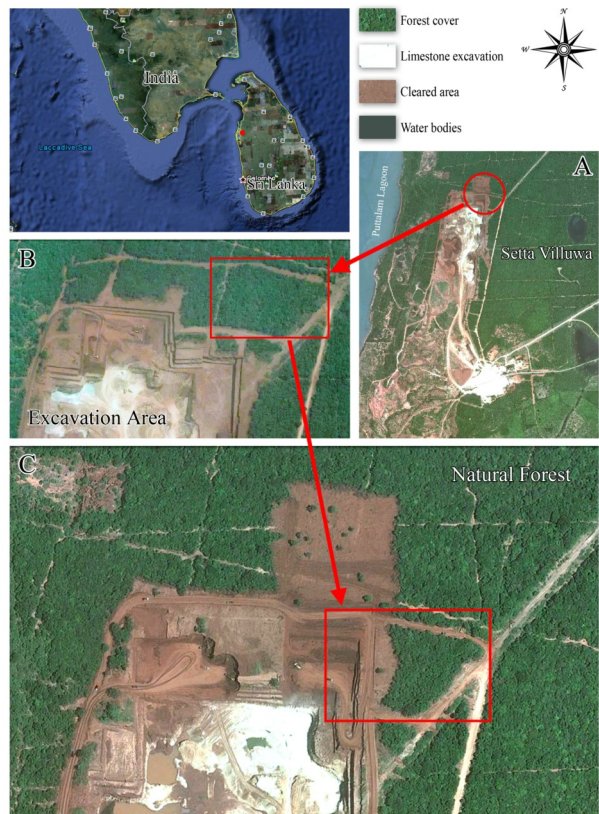
development to be sustainable. It has been repeatedly shown that mining has several adverse impacts that cannot be rectified (BBOP, 2009; Imboden *et al.*, 2010). Lime extraction from quarries for instance has the potential to affect biota both directly and indirectly, throughout its life cycle (Misra, 2002). The processes of quarrying, blasting, processing and transportation of products negatively affect the natural topography of the land whilst quarry waste or by-products become sources of environmental pollution (Montenegro *et al.*, 2005).

Surface water sources are severely depleted whilst water quality suffers as a result of soil erosion (Schmeisky *et al.*, 2002; Soorae, 2008). Apart from the large scale habitat clearance that would be detrimental to the biota, the emission of dust, noise, vibration would degrade the quality of neighboring areas that would render them unsuitable for plants and animals (Allington and White 2007). Additionally, the archeological heritage and geodiversity of quarry sites are also destroyed (Eurogypsum, 2009). It is encouraging that, such crucial projects although potentially destructive, strive to minimize the magnitude of destruction to natural environment by incorporating mitigatory processes (Misra, 2002). One such mitigatory process would be to reduce impacts on flora and fauna in areas that would be affected by the developmental activity.

Biodiversity assessments form an integral component of any conservation and management programme. Hence in this project we undertook a biodiversity survey at the Holcim quarry site (Eluwankulama Aruwakkalu Forest - EAF) to fulfill the objective of integrating aspects of conservation into quarry operations in an attempt to mitigate adverse impacts on species inhabiting the quarry site. The survey was conducted in areas earmarked for excavation and blasting. We systematically documented the flora and fauna within the site, and captured and translocated less mobile species.

### STUDY LOCALITY AND HABITATS

The Holcim quarry site, also known as the Eluwankulama Aruwakkalu Forest (EAF) ( $8^{\circ} 14' 58.10''$  to  $8^{\circ} 15' 32.65''$  N and  $79^{\circ} 49' 03.84''$  to  $79^{\circ} 49' 23.72''$  E) is located in the Puttalam District, approximately 35 km away from the Puttalam town (Figure 1).

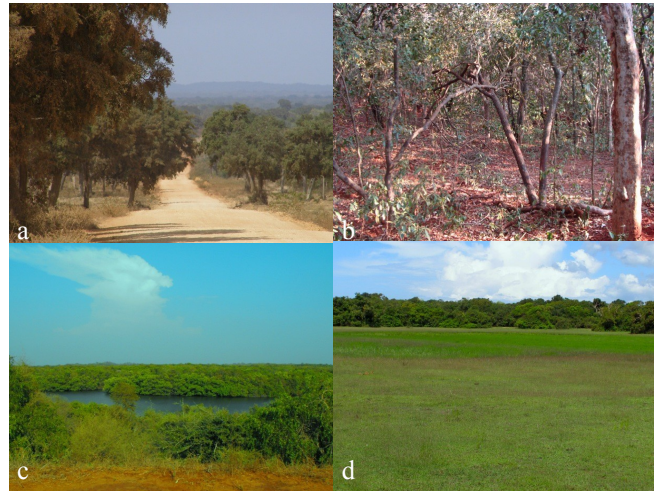


**Figure 1.** Map of the Holcim limestone excavation site (Eluwankulama Aruwakkalu Forest), Puttalam District, Sri Lanka (Red dot – Exact location; A, B – before clearing and C – after clearing the forest).

It has an elevation of about 20 m above mean sea level, and borders the Kalā-oya River (Karunaratna *et al.*, 2009). The average annual rainfall is <1100 mm, with most of the rain occurring during the months of November and December (Survey Department, 2007). Occasional showers occur at other times of the year. The weather becomes gradually drier from May to September with the highest temperatures being recorded during August (around  $34.8^{\circ}$  C). The mean annual temperature in the Puttalam area is  $29.6^{\circ}$  C with a minimum of

$25.4^{\circ}$  C (Survey Department, 2007). The average relative humidity is 75 % with the highest being recorded in December. The Holcim quarry site (Eluwankulama Aruwakkalu forest) situated in the dry zone of Sri Lanka consists of a unique forest type, which in turn supports a rich community of flora and fauna (Weerasinghe, 2008).

The unique landscape comprises of dry zone forests and thorny scrub interspersed with extensive open plains, sand dunes and freshwater Villu wetlands. The saucer-shaped ‘Villu’ wetlands in particular are a topographical feature unique to this area of the country (Figure 2).



**Figure 2.** a) Road side tall forest view, b) Dry mixed evergreen forest flow, c) Well established mangrove forest area in Gangewadiya, d) Villu habitat with native rice varieties in Holcim site.

The Holcim quarry (EAF) site is also noted for its archaeological significance, as it supports a fossil belt belonging to the Miocene period (Ma): mostly found invertebrate fossils. The forest vegetation of the area could be classified as dry-mixed evergreen forest and scrub forests (Gunatilleke and Gunatilleke, 1990), which are the typical vegetation types of the dry zone of Sri Lanka. The northern areas harbor mangrove vegetation. Each year Holcim (EAF) clears approximately six hectares of land. While large animals such as the elephants, deer, wild boar and birds move away from this area at the slightest hint of disturbance (Figure 3), other species tend to get trapped within it and as a result succumb to the large scale destruction.

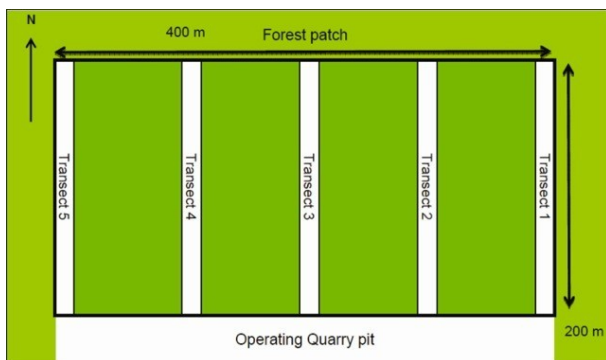
## MATERIALS AND METHODS

### *Biodiversity Assessments*

The biodiversity survey and the rescue operation at the proposed quarry site (EAF) were conducted during the months of October to December 2009. The survey was restricted to an area of 8 ha within the Holcim quarry site (EAF), which was earmarked for mining operations in 2010. Five strip transects each of  $100 \times 5$  m<sup>2</sup> were randomly located within this area (EAF) and marked with polythene tags (Figure 4). Systematic sampling of both plants and animals were then conducted along the marked



**Figure 3.** a) Original forest cover clearing, b) Drilling works by using heavy machines, c) Large scale mining area for limestone, d) Newly established mining area



**Figure 4.** Sketch of the sampling site and transects in proposed extension in Holcim limestone excavation site (Eluwankulama Aruwakkalu Forest).

areas. Each transect was surveyed for around 1 hour and surveys were conducted both during the day and at night. Additionally, the plants were systematically surveyed over a total extent of 2500 m<sup>2</sup> within the study area. The basal area, relative abundance, and frequency of occurrence of different tree species were recorded, to calculate the Important Value Index (IVI), which indicates the total contribution made by each species in determining the structure of the plant community. The basal area index was also calculated for each species using the girth at breast height (GBH) in trees. For both flora and fauna, opportunistic observations were also conducted within the entire quarry site. Considering the fauna, the amphibians, reptiles and ground dwelling invertebrates were primarily surveyed using the Visual Encounter Survey method (Crump and Scott, 1994; Magurran, 2004) conducted at night with the aid of headlamps and torches and the Quadrant Cleaning Method (QCM), where the litter is systematically cleared and searched whilst overturning logs and stones conducted during the day. Additionally, two pit-fall traps were placed along each transect and were checked twice a day for trapped animals. Road kills and data on animals killed by villages were also used as additional sources of information. The avifaunal data were collected using sightings and calls along transects marked for the flora. Mammals were

documented through direct observations and calls, and through indirect methods such as the presence of footprints, scat and other signs throughout the quarry site. Butterflies, which are an important group of insects found in rich abundance within the quarry site, were documented through observation, while hand nets were used to capture individuals when necessary for the purpose of identification. Theraphosid spiders were recorded by searching tree holes and leaf litter during both day and night. On some instances tree holes were slashed to locate spiders and geckos. Species lists were then constructed separately for each of the different taxonomic groups surveyed.

#### **Identification of species**

Many keys were used for the purpose of identification of taxa. The vertebrates and invertebrates were identified and classified using well known and most recently published field guides, e.g. Dutta and Manamendra-Arachchi (1996), de Silva (2009) and Manamendra-Arachchi and Pethiyagoda (2006) for amphibians; Bauer *et al.* (2010a and 2010b), De Silva (2006), Das and de Silva (2005), de Silva (1990), Praschag *et al.* (2011), Somaweera (2006), Somaweera and Somaweera (2009) and Whitaker and Captain (2004) for reptiles; Harrison (1999), Henry (1998), Kotagama and Wijayasinha (1998), Kotagama *et al.* (2006), Rasmussen and Anderton (2005) and Wijeyeratne *et al.* (2007) for birds; Weerakoon and Goonatilake (2006), Phillips (1980) for mammals; D'Abnera (1998), Gamage (2007), Perera and Bambaradeniya (2006), Woodhouse (1950) and Kunte (2006) for butterflies; Ashton *et al.* (1997), Dassanayake and Fosberg (1980-1991), Dassanayake *et al.* (1994-1995), Dassanayake and Clayton (1996-2000), Gunatilleke and Gunatilleke (1990) and Senaratna (2001) for floral classification. The lists of threatened species were based on the most recent national Red List (IUCN-SL and MENR-SL, 2007).

#### **Capture and translocation of species**

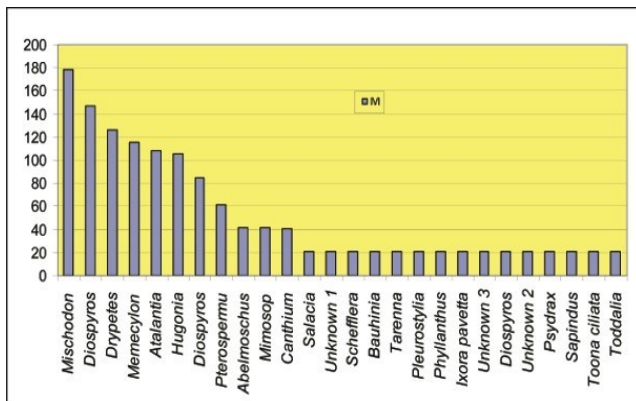
Rescue operations were also conducted during both day and night. Many animals were rescued both during the biodiversity assessment and during additional days dedicated solely for rescue operations. The special rescue operations enabled the capture and removal of as many animals within a short space of time. Butterflies were captured using hand nets. Animals collected in the pitfalls were also rescued. All captured animals were carefully collected into plastic containers and safely translocated to the Sethtavilluwa area and released in the vicinity of similar microhabitats and in unexposed areas. Identification of suitable habitats was based on a separate study carried out by IUCN Sri Lanka country office prior to the present study (IUCN-SL, 2008). The abandoned quarry pits (EAF) were rehabilitated by Holcim using plants uprooted during excavation.

## **RESULTS**

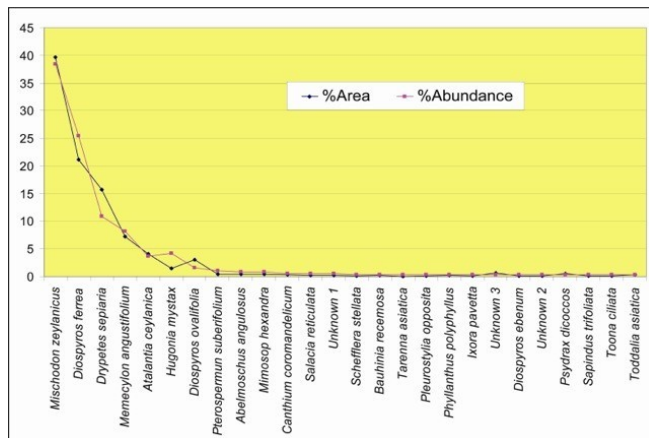
#### **Floral species richness and abundance**

A total of 41 trees (38 genera) and scrub species belonging to 24 families were recorded in the area (Appendix I). The vegetation in the study area mainly consists of the typical dry mixed evergreen forest dominated by the two species *Mimusops hexandra* (Pálü) and *Drypetes sepiaria*

(Wëërä). The Important Value Index was calculated separately for each of the 26 tree species. These values indicate that *Mischodon zeylanicus* (Thämmënnä) (Figure 5) was the species that made the highest contribution towards the vegetation structure of the study site. This species was equally spread among the transects, and was also the most common tree species, covering approximately 40% of the total area of the study site and contributing to 38% of the total abundance. *Diospyros ferrea* (Kálumëdiriyä) was the next commonest species covering about 21% of the study area (Figure 6).



**Figure 5.** The Important Value Indices (IVI) of the different tree species recorded at the study site.



**Figure 6.** Basal coverage and the percentage abundance of each tree species recorded at the study site.

The characteristic tree species in the area *D. sepiaria* (Wëërä) was placed third with respect to the area covered by a single species. This species covered an area of around 15% and had a percentage abundance of 11%. All other species together accounted for only 20% coverage of the study area. The relative abundance of the tree species in the study site is given in Table 1. Saplings of the tree *Mischodon zeylanicus* (Thämmënnä) and *D. ferrea* (Kálumëdiriyä) were common in the undergrowth.

In addition to the saplings of the large tree species, herbs or shrubs such as *Strobilanthea sp.* (Nëlü) *Memecylon angustifolium* (Kôra kahâ) and *Glycosmis pentaphylla* (Bol pâna) were also relatively

frequent in the undergrowth. The trees of varying height, ranging from 8m to 25m, are scattered forming open type vegetation.

**Table 1.** Density (number of trees per 1 m<sup>2</sup>), frequency (proportion of transects in which a species was recorded, FRV) and the Important Value Index (IVI) of each tree species at the study sites.

No. Trees	Density	FRV	IVI
145	38.36 %	5	178.06
96	25.40 %	5	146.59
41	10.85 %	5	126.51
31	8.20 %	5	115.44
14	3.70 %	5	107.75
16	4.23 %	5	105.71
06	1.59 %	4	84.63
04	1.06 %	3	61.50
03	0.79 %	2	41.18
03	0.79 %	2	41.22
02	0.53 %	2	40.83
02	0.53 %	1	20.72
02	0.53 %	1	20.72
01	0.26 %	1	20.32
01	0.26 %	1	20.46
01	0.26 %	1	20.29
01	0.26 %	1	20.32
01	0.26 %	1	20.52
01	0.26 %	1	20.38
01	0.26 %	1	20.87
01	0.26 %	1	20.39
01	0.26 %	1	20.34
01	0.26 %	1	20.78
01	0.26 %	1	20.34
01	0.26 %	1	20.34
01	0.26 %	1	20.57

**Richness of faunal species**

A total of 220 species belonging to 74 families and 178 genera were recorded from within the study site. They comprised 164 species of vertebrates, 51 butterflies and 5 of other invertebrates accounting for 74.5%, 23.3% and 2.3% of the fauna respectively, recorded from this forest (EAF). Table 2 summarizes the richness at both family and species levels for each of the taxonomic groups. Of these only 49 species of vertebrates and 21 species of butterflies which represented 29.8% of vertebrates, and 41.1% of butterflies were recorded along the surveyed transects. The vertebrates comprised 9.1% amphibians, 29.3% of reptiles, 45.1% of birds and 16.5% of mammals (Figure 7). Of the total species recorded, 23 species (10.4%) are endemics, whilst 9 species (4.0%) are nationally threatened. The Nationally Threatened species were *Elephas maximus* (Asian elephant), *Ratufa macroura* (Giant squirrel), *Felis chaus* (Jungle cat), *Prionailurus viverrinus* (Fishing cat), *Trachypithecus vetulus* (Purple-faced leaf monkey), *Liopeltis calamaria* (Reed snake),

*Chrysopelea taprobanica* (Sri Lankan flying snake), *Lissemys ceylonensis* (Sri Lanka flapshell turtle) and *Geochelone elegans* (Star tortoise) (IUCN-SL and MENR-SL, 2007).

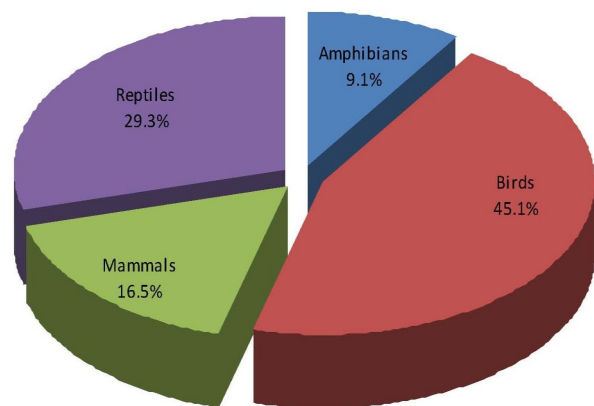
Among the seven families of amphibians recorded from Sri Lanka, five were recorded within the site (Appendix II). It is significant that species richness (15 species) of the study site represents approximately 14% of the total amphibian species recorded in the island although no nationally threatened species were recorded. Among these was one endemic (*Hylarana gracilis*) (Figure 8) species. Of the amphibians recorded, four species i.e. *Duttaphrynus melanostictus* (Common house toad), *Euphlyctis cyanophlyctis* (Skipper frog), *E. hexadactylus* (Sixtoe green frog) and *Hoplobatrachus crassus* (Jerdon's bull frog) were very common in the Eluwankulama forest, while *Microhyla rubra* and *Hylarana gracilis* were rare (Figure 9). Many isolated pools in the area served as breeding sites for these species. 20% of the island's reptilian fauna (Appendix III). The recorded species



**Figure 8.** Endemic Sri Lanka wood frog (*Hylarana gracilis*).

**Table 2.** Summary of the faunal and floral survey at the proposed mining site recorded during the present survey.

Taxonomic group	Families	Genera		Species		Threatened
		Total	Endemic	Total	Endemic	
Trees and Shrubs	24	38	00	41	01	00
Butterflies	05	40	00	51	00	00
Amphibians	05	12	00	15	01	00
Reptiles	15	34	01	48	12	04
Birds	29	63	00	74	04	00
Mammals	15	24	00	27	04	05
Other Invertebrates	05	05	00	05	01	00
<b>Total</b>	<b>98</b>	<b>216</b>	<b>01</b>	<b>261</b>	<b>23</b>	<b>09</b>



**Figure 7.** Faunal species composition of the Holcim limestone excavation site.

included 20 species of tetrapod reptiles and 28 species of serpentoid reptiles. Among these, four species are nationally threatened. The most significant record made during the survey was that of the endemic *Geckoella yakhuna* (Blotch bowfinger gecko), a very rare and highly threatened gecko species (Figure 10) affected by habitat loss. Furthermore, other rare and nationally threatened reptiles such as *Chamaeleo zeylanicus* (Sri Lankan Chamelion) (Figure 11), *Chrysopelea taprobanica* (Sri Lankan flying snake) (Figure 12) and *Liopeltis calamaria* (Reed Snake) were recorded in the proposed quarry site. The most common reptiles in the study area included *Calotes versicolor* (Common garden lizard), *Hemidactylus parvimaculatus* (Spotted house-gecko), *Hemidactylus frenatus* (Common house-gecko), *Ptyas mucosa* (Rat snake) and *Varanus bengalensis* (Land monitor).



**Figure 9.** Balloon frog (*Uperodon systoma*).

Several reptile specimens were found as road kills during the study period, which included *Ahaetulla pulverulenta* (Brown vine snake), *Lissemys ceylonensis* (Sri Lanka flapshell turtle), *Rhinophis cf. porrectus* (unidentified Earth snake sp.) (Figure 13), *Typhlops* sp. (unidentified Blind snake sp.). Sri Lanka's second largest reptile, the mugger crocodile (*Crocodylus palustris*) and the largest snake in Sri Lanka, python (*Python molurus*) were also recorded from this area. *Hemidactylus frenatus* (Common house-gecko) was the most dominant gecko

species recorded at the site, while *Sitana ponticeriana* (Fanthroat lizard) was the dominant agamid lizard species. Of the snakes, *Ramphotyphlops cf. braminus* (Common blind snake) was the most abundant.



**Figure 10.** Blotch bowfinger gecko (*Geckoella yakhuna*).



**Figure 11.** Sri Lankan chameleon (*Chamaeleo zeylanicus*).



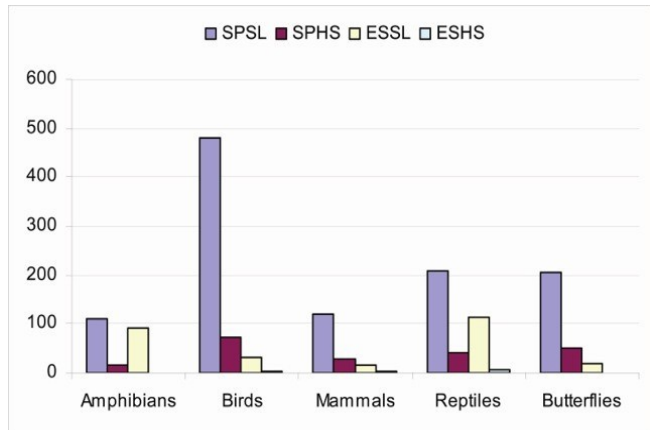
**Figure 12.** Endemic striped flying snake (*Chrysopelea taprobanica*).



**Figure 13.** Earth snake sp (*Rhinophis cf. porrectus*).

The reptile family in which the largest number of species was recorded was Colubridae (16 species), followed by Gekkonidae (5 species), Agamidae (4 species), Elapidae (3 species) and Scincidae (3 species). Of the five *Boiga* spp. (Cat snakes) in Sri Lanka four were recorded at the site.

Birds were the most dominant group of vertebrates at the Eluwankulama forest, consisting of 74 species (3 endemics) belonging to 29 families (Appendix IV). The avifauna of the study area represented approximately 15.4% of the species recorded in Sri Lanka (Figure 14).

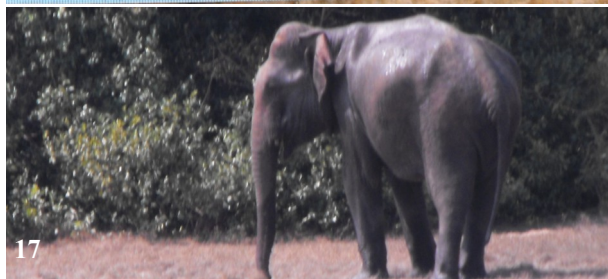


**Figure 14.** Comparison of the total faunal species richness and endemic species richness in the Holcim limestone excavation site with that of Sri Lanka (SPSL-species in Sri Lanka, SPHS-species in Aruwakkalu site, ESSL-endemic species in Sri Lanka and ESHS-endemic species in Holcim site).

The four endemics were *Gallus lafayetii* (Jungle fowl), *Ocyrceros gingalensis* (Grey Hornbill), *Treron pompadora* (Sri Lanka Green-pigeon) and *Pelloroneum fuscicapillum* (Brown-capped Babbler). None of the species recorded were, however, nationally threatened. Both terrestrial and aquatic species were recorded in the area (Figure 15). Of the birds, *Pycnonotus cafer* (red-vented bulbul), *Megalaima zeylanica* (Brown headed Barbet), *Gallus lafayetii* (Sri Lanka Junglefowl), *Psittacula krameri* (Rose-ringed Parakeet), *Treron bicincta* (Orange-breasted Green-pigeon), *Pycnonotus luteolus* (White-browed Bulbul) and *Pavo cristatus* (Indian Peafowl) were very common, while *Milvus migrans* (Black Kite), *Pelloroneum fuscicapillum* (Brown-capped Babbler), *Dicrurus macrocercus* (Black Drongo), *Hypothymis azurea* (Black-naped Monarch) and *Lonchura malacca* (Black-headed Munia) were rare species. Several dead specimens of *Pitta brachyura* (Indian pitta) were recorded within the site during the study period (Figure 16).

Considering the mammals, a total of 27 species (4 endemics) belonging to 15 families, were recorded (detailed list is provided in Appendix V), which amounts to around 23% of the island's mammalian fauna. Among them were five species of nationally threatened species. *Macaca sinica* (Macaque monkey), *Canis aureus* (Jackal), *Herpestes edwardsii* (Grey mongoose), *Elephas maximus* (Asian Elephant) (Figure 17), *Sus scrofa* (Wildboar), *Tatera indica* (Antelope rat) (Figure 18), *Viverricula indica* (Ring-tailed civet) and *Lepus nigricollis* (Black-naped hare) were common, while *Manis crassicaudata*

(Pangolin), *Loris lydekkerianus* (Grey slender loris) (Figure 19) and *Prionailurus viverrinus* (Fishing cat) were rare in the Eluwankulama quarry site. A few troops (2 to 4) of the endemic *Trachypithecus vetulus* (Purple-faced leaf monkey) were observed along the network of riverine forests near the Kala Oya river mouth.

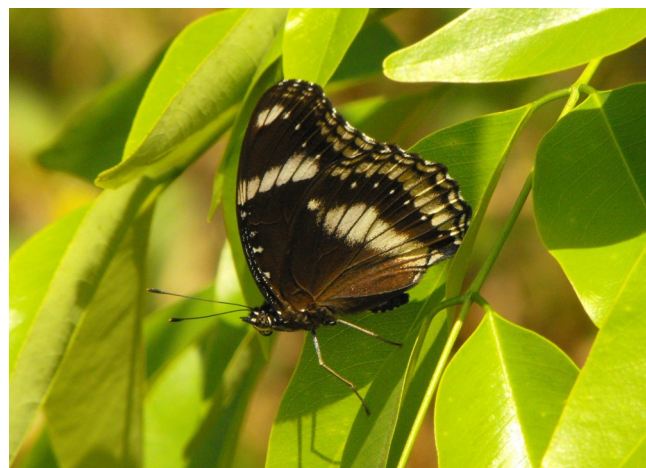


**Figure 15.** Asian Paradise-flycatcher (*Terpsiphone paradisi*); **Figure 16.** Indian Pitta (*Pitta brachyura*); **Figure 17.** Asian Elephant (*Elephas maximus*); **Figure 18.** Antelope rat (*Tatera indica*); **Figure 19.** Grey slender loris (*Loris lydekkerianus*).

A rich array of butterflies was recorded in the Eluwankulama forest, which comprised of 51 species belonging to 5 families (Appendix VI). The butterflies represented approximately 25 % of the total species in the island. Among the recorded species, *Ixias pyrene* (Yellow orange tip), *Euploea core* (Common crow), *Pachliopta aristolochiae* (Common rose), *Delias eucharis* (Jezebel), *Catopsilia pyranthe* (Mottled emigrant), *Eurema hecabe* (Common grass yellow) (Figure 20), *Danaus chrysippus* (Plain tiger), *Ypthima ceylonica* (White four-ring) and *Junonia lemonias* (Lemon pansy) were the most abundant. Conversely, *Papilio polymnestor* (Blue mormon), *Pathysa nomius* (Spot swordtail), *Hebomoia glaucippe* (Great orange tip), *Hypolimnas misippus* (Danaid Eggfly) (Figure 21), *Euthalia aconthea* (Baron), *Curetis thetis* (Indian sunbeam), *Tirumala limniace* (Blue tiger) and *Zesius chrysomallus* (Redspot) were rare. The largest number of species was from the family Nymphalidae (19 species), followed by the families Lycaenidae (13 species), Pieridae (10 species), Papilionidae (7 species) and Hesperidae (2 species).



**Figure 20.** Common grass yellow (*Eurema hecabe*).



**Figure 21.** Danaid Eggfly (*Hypolimnas misippus*).

### Capture and translocation of fauna

A large number of animals (226) were captured and translocated (Figure 22) during this conservation project (Table 3). The majority of the animals rescued were reptiles (53%), which included a total of 120



**Figure 22.** Simple equipments and containers were used for rescue.

individuals belonging to 22 species. Rescued reptiles included 31 individuals of the six endemics: *Otocryptis nigristigma* (Black spotted kangaroo Lizard), *Geckoella yakhuna* (Blotch bowfinger Gecko), *Hemidactylus lankae* (Termite hill Gecko), *Chrysopelea taprobanica* (Striped flying Snake), *Dendrelaphis bifrenalis* (Boulenger's Bronze-back) and *Lycodon osmanhilli* (Flowery wolf Snake). Of these, one species of snake (*C. taprobanica*) is categorized as a nationally threatened species. A large number of invertebrates were also rescued during the operation. Of the rescued invertebrates 27 individuals were of the endemic tarantula (*Poecilotheria fasciata*) (Figure 23) which included both juvenile and adult stages (Appendix VII). A few species of land snails, Whipscorpions, Scorpions, Pseudoscorpions and Tailless whipscorpion were also rescued.

**Table 3.** The number of animals in each taxonomic group rescued from the proposed quarry site during the study (En = Endemic / Ind = Individulas / Thr = Threatened).

Faunal Group	No. Ind.	En .	En. Ind.	Th r.	Thr. Ind.
Amphibians	15	00	00	00	00
Mammals	6	01	01	00	00
Reptiles	120	06	31	01	02
Invertebrates	85	01	27	00	00
<b>Total</b>	<b>226</b>	<b>08</b>	<b>59</b>	<b>01</b>	<b>02</b>

Fifteen individuals of amphibians (3 families) belonging to four species *Duttaphrynus melanostictus* (Common house Toad), *Kaloula taprobanica* (Common bull Frog), *Uperodon systoma* (Balloon Frog) and *Fejervarya limnocharis* (Common paddy

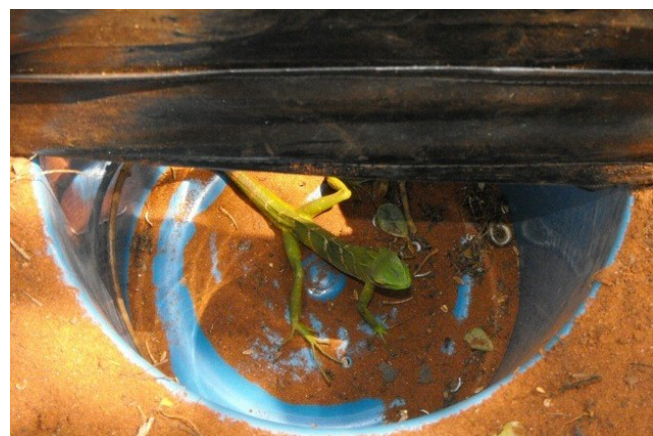
field Frog) were also captured and relocated. A few mammals (6 individuals) belonging to four species: *Loris lydekkerianus* (Grey slender Loris), *Rattus rattus* (Common Rat), *Tatera indica* (Antelope Rat) and *Vandeleuria oleracea* (Long-tailed tree Mouse) were relocated at a suitable site. It is noteworthy that the loris *Loris lydekkerianus* was among the species of mammals that were rescued. But two individuals of *Rattus rattus* (Common rat) known to be invasive were also rescued considering internationally accepted animal ethics (FERC-SL, 2009; Waples and Stagoll, 1997) (Figures 24 and 25).



**Figure 23.** Bird-eating Spider (*Poecilotheria fasciata*).



**Figure 24.** Cross type pitfall trap (20m width and 50m long).



**Figure 25.** Common garden lizard (*Calotes calotes*) trap in the bucket.



## DISCUSSION

The present survey revealed that the Holcim Quarry site (EAF) supported a rich assemblage of both flora and fauna. This is to be expected because although the area is predominantly composed of dry monsoon forests, a mosaic of microhabitats is found in the area which includes riverine vegetation, grasses, marsh vegetation and mangroves which in turn provide niches for a wide variety of both invertebrates and vertebrates. Other studies conducted in the island have also revealed that the monsoon forests of the dry zone harbours rich communities of both plants and animals (eg. Bambaradeniya *et al.*, 2002; Perera *et al.*, 2005; Weeratunga, 2009; Weerasinghe, 2008). It was observed that the birds were the most abundant faunal group within the proposed quarry site whilst amphibians were the least abundant. The study site did not support a large number of endemics. This is to be expected because reproductive isolation of the dry zone forests were prevented due to the similar climatic conditions found in the southern most tip of India (Kunte, 2006; Rajagopal *et al.*, 2011; Van der Poorten and Van der Poorten, 2011a; 2011b). Many of the endemics in Sri Lanka are concentrated in the southwestern wet-zone.

The habitat conditions of the dry zone are conducive for the reptiles but less so for the amphibians. Bufonids that are more adapted to drier conditions were more frequent than those in the other families. This has been shown in many studies conducted in the dry zone (De Silva and De Silva, 2004; Karunarathna *et al.*, 2008). Among the recorded amphibians were litter-dwelling, fossorial, arboreal and aquatic species testifying to the diversity of the microhabitats found within the study site (Burgett *et al.*, 2007; Kapfer *et al.*, 2007; Gray *et al.*, 2007). Many of these amphibian species were also observed after a brief spell of rain because they use the temporary pools for breeding. The submerged grasslands, pools, ponds and tree holes inside the Holcim quarry site (EAF) were also inhabited by many amphibian species (Karunarathna *et al.*, 2012). Such temporary water pools are a much valuable resource for aquatic amphibians as well as others (Relyea, 2004). As opposed to the amphibians, reptiles were found in abundance, with the common species in the area being more frequently observed. This area also supports three lethally poisonous snakes namely *Bungarus caeruleus* (Common krait), *Daboia russelii* (Russell's viper) and *Naja naja* (Indian cobra).

Although lower in species richness and endemic diversity than wet zone forests, the dry zone forests of the quarry site was a haven for birds. Around half of the species recorded were those associated with wetland ecosystems. In this respect the conservation of submerged grasslands known as the villu habitats are critical for the protection of these species. The protection of birds is also important as it may be a functional link in such mosaic environments (Ekanayake *et al.* 2005; IUSN-SL and CEA-SL, 2006). Wetland birds included herons, egrets, cormorants and kingfishers.

This area serves as a preferred feeding and resting grounds for several migrant species such as *Pitta brachyura* (Indian pitta), *Lanius cristatus* (Brown Shrike), *Milvus migrans* (Black kite). Many of the the waders use the mudflats and sand dunes found in the Puttalam area. With regard to the mammals, several important species including endemics and threatened species were recorded from the study site. Among them, *Elephas maximus* (Asian Elephant) were observed as small resident groups (4 to 10 individuals). But some migrate seasonally from the Wilpattu National Park area crossing the Thabbowa Sanctuary and are hence observed as large herds. Elephant dung was seen to be an important microhabitat for both amphibians and reptiles such as *Microhylla rubra* (Red narrow mouth frog) and *Lygosoma punctatus* (Dotted skink). This has also been documented by others (e.g. Campos-Arceiz, 2009; Pers. Obser. 2010). All the primates recorded in the dry zone of country were recorded from this site. The Slender Loris (*Loris lydekkerianus*) had a healthy population, using the quarry site as a feeding ground. A small group of the Purple-faced leaf monkey (*Trachypithecus vetulus*), one of the 25 most endangered primates in the world (Mittermeier *et al.*, 2009), was also a significant record at the study site. They usually avoid humans and live in the riverine forests close to the Kala-Oya. Although it is reported to be a pest in the wet zone (Rudran, 2007), but no such records were documented from the villages adjacent to the study site.

With respect to butterflies, the scrub forests are open habitats exposed to sunlight and are therefore ideally suited for them (Asela *et al.*, 2009; Woodhouse, 1950). It was apparent that the Holcim Quarry site supports a rich assemblage of flowering plants which no doubt provided ideal feeding and resting sites for the butterflies. The highest diversity of butterflies was recorded from the scrub forests in EAF while the lowest diversity was recorded in interior forest areas. This phenomenon is also observed in rainforests, where the butterflies usually frequent the open secondary forests than the thick core forest areas (Alwis *et al.*, 2005; Henkanaththegedara *et al.*, 2005; Karunarathna *et al.*, 2011). It is interesting to note that this vast diversity of butterflies did not contain a single endemic species.

Several threats were noted for the herpetofauna in the area. Snakes, both venomous and non-venomous species, are frequently killed in this area due to fear and ignorance, as a precautionary measure against snakebites (De Silva, 2006; Karunarathna and Perera, 2010). Another significant threat to both snakes and amphibians is the traffic which results in road kills. A large number of road kills were recorded after the rains, which have been noted by others elsewhere in the world (e.g. Glista *et al.*, 2008; Karraker, 2007). Flesh of turtles and tortoises (including star tortoise) is consumed by the people in nearby villages and the shells are used to produce ornaments. Information from local people and field evidence gathered during the survey indicate that there is illegal timber extraction for commercial purposes in the quarry site, especially in the northern part of the EAF. This occurs mainly in accessible areas with the use of chainsaws (Figure 26). The Gange-wadiya, Karativu and Eluwankulama fishing sites are frequently exposed to such illegal felling of trees.



**Figure 26.** Illegal timber (*Mimusops hexandra*) felling site at the Holcim site.

## RECOMMENDATIONS

Based on the observations made during the present study, the following recommendations are proposed to integrate biodiversity conservation aspects into limestone quarry operations:

### (1) Need for baseline studies to aid in restoration

Habitat destruction and disturbance caused by blasting and excavation remain the predominant threats to the biota of Holcim quarry sites (EAF). Biodiversity surveys such as the present one will provide invaluable baseline information that would facilitate restoration, and rehabilitation of natural habitats, in areas where limestone extractions have been completed.

### (2) Management of Invasive Alien Species

Spread of invasive alien plants species in the restoration area needs to be managed, in order to facilitate the growth of native species. Invasive species such as *Eupatorium odoratum*, *Lantana camara* and *Xanthium indicum* were found extensively in the peripheral areas of the water bodies, particularly around human settlements. Under brushed areas and flanking jeep tracks are gradually being invaded by species such as *Chrysopogon aciculatus*, *Croton officinalis*, *Eupatorium odoratum*, *Hyptis suaveolens*, *Imperata cylindrica* and *Vernonia cinerea* that are invasive or have near invasive characteristics. A relatively large number of domestic dogs (*Canis familiaris*) and domestic cat (*Felis catus*) were observed around the Holcim site. These domestic dogs can pose a threat to wildlife populations since they hunt small mammals, reptiles and birds.

### (3) Regular monitoring

Regular monitoring of restored areas is of crucial importance. The survival of the translocated animals as well as their habitats needs to be regularly monitored to ensure the success of the rescue efforts.

### (4) Create awareness among quarry workers

One of the main advantages of biodiversity assessments is that it increases interactions between local communities and quarry site operational staff resulting in greater awareness among villagers about the value of conserving the species and their habitats. Settlers in buffer zone

areas, security personnel and local governmental authorities have little awareness of the biotic richness of the quarry site and are hence insensitive towards the need to conserve it. This initiative has shown that the integration of awareness programmes into conservation and management plans will without doubt facilitate better management of the quarry sites and their biodiversity (Figure 27).



**Figure 27.** Field team and the watch guard (Holcim) with five Sri Lankan chameleons (*Chamaeleo zeylanicus*), first time in the Sri Lanka history.

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**Appendix 1.** List of plant species recorded from the study area, EAF. (E – Endemic species).

Family and Species	Common Name
<b>Acanthaceae</b>	
<i>Strobilanthea sp.</i>	Nelu
<b>Apocynaceae</b>	
<i>Carissa spinarum</i>	Heen karaba
<b>Araliaceae</b>	
<i>Schefflera stellata</i>	Ittha
<b>Asteraceae</b>	
<i>Eupatorium odoratum</i>	Wathupalu
<b>Bombacaceae</b>	
<i>Ceiba pentandra</i>	Imbul
<b>Capparaceae</b>	
<i>Capparis rotundifolia</i>	
<b>Celastraceae</b>	
<i>Pleurostyliia opposita</i>	Panakka
<i>Cassine balae</i>	Neraloo <sup>E</sup>
<b>Ebenaceae</b>	
<i>Diospyros ebenum</i>	Kaluwara
<i>Diospyros ovalifolia</i>	Kunumella
<i>Diospyros Ferrea</i>	
<b>Euphorbiaceae</b>	
<i>Mischodon zeylanicus</i>	Thammanna
<i>Phyllanthus polyphyllus</i>	Kuratiya
<i>Drypetes sepiaria</i>	Weera
<b>Fabaceae</b>	
<i>Tephrosia purpurea</i>	Katuru pila
<i>Cassia auriculata</i>	Rana wara
<i>Cassia fistula</i>	Ehala
<i>Dichroatachys cinerea</i>	Andara
<b>Hippocrateaceae</b>	
<i>Salacia reticulata</i>	Kotala himbutu
<b>Laminaceae</b>	
<i>Ocimum tenuiflorum</i>	Maduru thala
<b>Linaceae</b>	
<i>Hugonia mystax</i>	Bu getiya
<b>Malvaceae</b>	
<i>Sida acuta</i>	Babila
<i>Abelmoschus angulosus</i>	Kapu kinissa
<b>Melastomataceae</b>	
<i>Memecylon angustifolium</i>	Kora kaha
<b>Myrtaceae</b>	
<i>Syzygium cumini</i>	Madam

**Rhamnaceae***Zizyphus rugosa* Eraminiya**Rubiaceae***Canthium coromandelicum* Kara*Morinda coreia* Ahu*Ixora coccignea* Rathmal*Psydrax dicoccos**Tarenna asiatica* Tarana**Rutaceae***Atalantia ceylanica* Yakinaran*Glycosmis pentaphylla* Bol pana*Toddalia asiatica* Kudu miris**Sapindaceae***Sapindus emarginata* Kaha penela**Sapotaceae***Mimusops hexandra* Palu**Sterculiaceae***Pterospermum suberifolium* Welan**Ulmaceae***Trema orientalis* Gadumba**Verbenaceae***Gmelina asiatica* Demata*Vitex altissima* Milla*Lantana camara* Gandapana

**Appendix II.** List of amphibian species recorded from the study area (E – Endemic species).

Family and Species	Common Name
<b>Bufonidae</b>	
<i>Bufo scaber</i>	Schneider's toad
<i>Duttaphrynus melanostictus</i>	Common house toad
<b>Microhylidae</b>	
<i>Kaloula taprobanica</i>	Common bull frog
<i>Microhyla ornata</i>	Ornate narrow mouth frog
<i>Microhyla rubra</i>	Red narrow mouth frog
	White-bellied pugsnout frog
<i>Ramanella variegata</i>	Balloon frog
<i>Uperodon systoma</i>	Balloon frog
<b>Dicroglossidae</b>	
<i>Euphlyctis cyanophlyctis</i>	Skipper frog
<i>Euphlyctis hexadactylus</i>	Sixtoe green frog
	Common paddy field frog
<i>Fejervarya limnocharis</i>	Jerdon's bull frog
<i>Hoplobarachus crassus</i>	Banded sand frog
<i>Sphaerotheca breviceps</i>	Marbled sand frog
<i>Sphaerotheca rolandae</i>	Marbled sand frog
<b>Ranidae</b>	
<i>Hylarana gracilis</i>	Sri Lanka wood frog <sup>E</sup>
<b>Rhacophoridae</b>	
<i>Polypedates maculatus</i>	Spotted tree frog

**Appendix III:** List of reptile species recorded from the study area (E – Endemic species / VU - Vulnerable).

Family and Species	Common Name
<b>Agamidae</b>	
<i>Calotes caloes</i>	Green garden lizard
<i>Calotes versicolor</i>	Common garden lizard
	Black spotted kangaroo lizard <sup>E</sup>
<i>Otocryptis nigristigma</i>	Fanthroat lizard
<i>Sitana ponticeriana</i>	Fanthroat lizard
<b>Chameleontidae</b>	
<i>Chamaeleo zeylanicus</i>	Sri Lankan chameleon
<b>Gekkonidae</b>	
<i>Geckoella yakhuna</i>	Blotch bowfinger gecko <sup>E</sup>
<i>Hemidactylus parvimalatus</i>	Spotted house-gecko
<i>Hemidactylus frenatus</i>	Common house-gecko
<i>Hemidactylus leschenaultii</i>	Bark gecko
<i>Hemidactylus lankae</i>	Termite hill gecko <sup>E</sup>
<b>Scincidae</b>	
<i>Eutropis carinata</i>	Common skink
<i>Eutropis macularia</i>	Bronzegreen little skink
<i>Eutropis tammanna</i>	Tammenna skink <sup>E</sup>
<i>Lankascincus fallax</i>	Common lanka skink <sup>E</sup>
<i>Lygosoma punctatus</i>	Dotted skink
<b>Varanidae</b>	
<i>Varanus bengalensis</i>	Land monitor
<b>Bataguridae</b>	
<i>Melanochelys trijuga</i>	Parker's black turtle
<b>Testudinidae</b>	
<i>Geochelone elegans</i>	Star tortoise <sup>VU</sup>
<b>Trionychidae</b>	
	Sri Lanka flapshell turtle <sup>E/VU</sup>
<i>Lissemys ceylonensis</i>	
<b>Crocodylidae</b>	
<i>Crocodylus palustris</i>	Mugger crocodile
<b>Boidae</b>	
<i>Python molurus</i>	Indian python
<b>Colubridae</b>	
<i>Ahaetulla nasuta</i>	Green vine snake
<i>Ahaetulla pulverulenta</i>	Brown vine snake
<i>Amphiesma stolatum</i>	Buff striped keelback
<i>Boiga ceylonensis</i>	Sri Lanka cat snake
<i>Boiga beddomei</i>	Beddome's cat snake
<i>Boiga forsteni</i>	Forsten's catsnake
<i>Boiga trigonatus</i>	Gamma cat snake
<i>Chrysopelea taprobanica</i>	Striped flying snake <sup>E/VU</sup>
<i>Coeloganthus helena</i>	Trinket snake
<i>Dendrelaphis bifrenalis</i>	Boulenger's Bronze-back <sup>E</sup>
<i>Dendrelaphis tristis</i>	Common bronze back
<i>Liopeltis calamaria</i>	Reed snake <sup>VU</sup>
<i>Lycodon aulicus</i>	Wolf snake
<i>Lycodon striatus</i>	Shaw's wolf snake

<i>Oligodon arnensis</i>	Common kukri snake
<i>Oligodon taeniolata</i>	Variiegated kukri snake
<i>Ptyas mucosa</i>	Rat snake
<i>Xenochrophis cf. piscator</i>	Checkered Keelback <sup>E</sup>
<b>Elapidae</b>	
<i>Bungarus caeruleus</i>	Common krait
<i>Calliophis melanurus</i>	Sri Lanka coral snake
<i>Naja naja</i>	Indian cobra
<b>Typhlopidae</b>	
<i>Ramphotyphlops cf. braminus</i>	Common blind snake
<i>Typhlops</i> sp.	Blind snake sp. <sup>E</sup>
<b>Uropeltidae</b>	
<i>Rhinophis oxyrynchus</i>	Schneider's earth snake <sup>E</sup>
<i>Rhinophis cf. porrectus</i>	Eearth snake sp. <sup>E</sup>
<b>Viperidae</b>	
<i>Daboia russelii</i>	Russell's viper
	Merrem's hump-nose viper
<i>Hypnale hypnale</i>	viper

**Appendix IV.** List of avifaunal species recorded from the study area (E – Endemic species).

Family and Species	Common Name
<b>Phasianidae</b>	
<i>Francolinus pondicerianus</i>	Grey Francolin
<i>Gallus lafayetii</i>	Sri Lanka Junglefowl <sup>E</sup>
<i>Pavo cristatus</i>	Indian Peafowl
<b>Magalaimidae</b>	
<i>Megalaima zeylanica</i>	Brown-headed Barbet
<i>Megalaima haemacephala</i>	Coppersmith Barbet
<b>Bucerotidae</b>	
<i>Ocyrceros gingalensis</i>	Sri Lanka Grey Hornbill <sup>E</sup>
<i>Anthraceroceros coronatus</i>	Malabar Pied Hornbill
<b>Alcedinidae</b>	
<i>Halcyon capensis</i>	Stork-billed Kingfisher
<i>Halcyon smyrnensis</i>	White-throated Kingfisher
<i>Alcedo atthis</i>	Common Kingfisher
<b>Cerylidae</b>	
<i>Ceryle rudis</i>	Pied Kingfisher
<b>Meropidae</b>	
<i>Merops orientalis</i>	Green Bee-eater
<i>Merops philippinus</i>	Blue-tailed Bee-eater
<b>Cuculidae</b>	
<i>Clamator jacobinus</i>	Pied Cuckoo
<i>Cuculus micropterus</i>	Indian Cuckoo
<i>Eudynamys scolopacea</i>	Asian Koel

<i>Phaenicophaeus viridirostris</i>	Blue-faced Malkoha
<b>Centropodidae</b>	
<i>Centropus sinensis</i>	Greater Coucal
<b>Psittacidae</b>	
<i>Psittacula krameri</i>	Rose-ringed Parakeet
<b>Apodidae</b>	
<i>Collocalia unicolor</i>	Indian Swiftlet
<b>Columbidae</b>	
	Orange-breasted Green-pigeon
<i>Treron bicincta</i>	
<i>Treron pompadora</i>	Sri Lanka Green-pigeon <sup>E</sup>
<i>Streptopelia chinensis</i>	Spotted Dove
<i>Ducula aenea</i>	Green Imperial Pigeon
<b>Charadriidae</b>	
<i>Vanellus indicus</i>	Red-wattled Lapwing
<b>Accipitridae</b>	
<i>Milvus migrans</i>	Black Kite
<i>Haliastur indus</i>	Brahminy Kite
<i>Ichthyophaga ichthyaeus</i>	Grey-headed Fish-eagle
<i>Accipiter badius</i>	Shikra
<i>Spizaetus cirrhatus</i>	Changeable Hawk Eagle
<i>Haliaeetus leucogaster</i>	White-bellied Sea-eagle
<b>Pittidae</b>	
<i>Pitta brachyura</i>	Indian Pitta
<b>Corvidae</b>	
<i>Corvus macrorhynchos</i>	Large-billed Crow
<i>Dicrurus macrocercus</i>	Black Drongo
<i>Oriolus xanthornus</i>	Black-hooded Oriole
<i>Hypothymis azurea</i>	Black-naped Monarch
<i>Aegithina tiphia</i>	Common Iora
<i>Terpsiphone paradisi</i>	Asian Paradise-flycatcher
<b>Muscicapidae</b>	
<i>Copsychus saularis</i>	Oriental Magpie Robin
<i>Saxicoloides fulvicata</i>	Indian Robin
<i>Copsychus malabaricus</i>	White-rumped Shama
<b>Sturnidae</b>	
<i>Acridotheres tristis</i>	Mynah
<b>Pycnonotidae</b>	
<i>Pycnonotus cafer</i>	Red-vented Bulbul
<i>Pycnonotus luteolus</i>	White-browed Bulbul

<b>Sylviidae</b>	
<i>Orthotomus sutorius</i>	Tailorbird
<i>Pellorneum fuscocapillum</i>	Brown-capped Babbler <sup>E</sup>
<i>Phylloscopus magnirostris</i>	Large-billed Leaf Warbler
<i>Rhopocichla atriceps</i>	Dark-fronted Babbler
<i>Turdoides affinis</i>	Yellow-billed Babbler
<b>Nectariniidae</b>	
<i>Dicaeum erythrorhynchos</i>	Pale-billed Flowerpecker
<i>Nectarina lotenia</i>	Loten's Sunbird
<i>Nectarina zeylonica</i>	Purple-rumped Sunbird
<b>Laniidae</b>	
<i>Lanius cristatus</i>	Brown Shrike
<b>Hemiprocnidae</b>	
<i>Hemiproctne coronata</i>	Crested Treeswift
<b>Coraciidae</b>	
<i>Coracias benghalensis</i>	Indian Roller
<b>Cisticolidae</b>	
<i>Prinia sylvatica</i>	Jungle Prinia
<i>Prinia inornata</i>	Plain Prinia
<b>Strigidae</b>	
<i>Ketupa zeylonensis</i>	Brown Fish Owl
<b>Caprimulgidae</b>	
<i>Caprimulgus atripennis</i>	Jerdon's Nightjar
<i>Caprimulgus asiaticus</i>	Common Nightjar
<b>Phalacrocoracidae</b>	
<i>Phalacrocorax fuscicollis</i>	Indian Cormorant
<i>Phalacrocorax carbo</i>	Great Cormorant
<i>Phalacrocorax niger</i>	Little Cormorant
<b>Ardeidae</b>	
<i>Egretta garzetta</i>	Little Egret
<i>Ardea cinerea</i>	Grey Heron
<i>Ardea purpurea</i>	Purple Heron
<i>Casmerodius albus</i>	Great Egret
<i>Mesophoyx intermedia</i>	Intermediate Egret
<i>Bubulcus ibis</i>	Cattle Egret
<i>Ardeola grayii</i>	Pond Heron
<b>Passeridae</b>	
<i>Passer domesticus</i>	House Sparrow
<i>Anthus rufulus</i>	Paddyfield Pipit
<i>Lonchura striata</i>	White-rumped Munia
<i>Lonchura malacca</i>	Black-headed Munia

**Appendix V.** List of mammal species recorded from the study area (E – Endemic species / VU - Vulnerable).

Family and Species	Common Name
<b>Manidae</b>	
<i>Manis crassicaudata</i>	Pangolin
<b>Cercopithecidae</b>	
<i>Macaca sinica</i>	Sri Lanka toque monkey <sup>E</sup>
<i>Semnopithecus priam</i>	Grey langur
<i>Trachypithecus vetulus</i>	Purple-faced leaf monkey <sup>E / VU</sup>
<b>Lorisidae</b>	
<i>Loris lydekkerianus nordicus</i>	Grey slender loris <sup>E</sup>
<b>Canidae</b>	
<i>Canis aureus</i>	Jackal
<b>Herpestidae</b>	
<i>Herpestes brachyurus</i>	Brown mongoose
<i>Herpestes edwardsii</i>	Grey mongoose
<i>Herpestes smithii</i>	Black-tipped mongoose
<b>Elephantidae</b>	
<i>Elephas maximus</i>	Elephant <sup>VU</sup>
<b>Cervidae</b>	
<i>Axis axis</i>	Spotted deer
<i>Muntiacus muntjak</i>	Barking deer
<b>Suidae</b>	
<i>Sus scrofa</i>	Wild boar
<b>Tragulidae</b>	
<i>Moschiola meminna</i>	Sri Lanka mouse-deer <sup>E</sup>
<b>Hystricidae</b>	
<i>Hystrix indica</i>	Porcupine
<b>Sciuridae</b>	
<i>Funambulus palmarum</i>	Palm squirrel
<i>Ratufa macroura</i>	Giant squirrel <sup>VU</sup>
<b>Leporidae</b>	
<i>Lepus nigricollis</i>	Black-naped hare
<b>Felidae</b>	
<i>Felis chaus</i>	Jungle cat <sup>VU</sup>
<i>Prionailurus viverrinus</i>	Fishing cat <sup>VU</sup>
<b>Viverridae</b>	
<i>Paradoxurus hermaphoditus</i>	Palm cat
<i>Viverricula indica</i>	Ring-tailed civet
<b>Muridae</b>	
<i>Bandicota bengalensis</i>	Mole rat
<i>Bandicota indica</i>	Malabar bandicoot
<i>Rattus rattus</i>	Common rat
<i>Vandeleuria oleracea</i>	Long-tailed tree mouse
<i>Tatera indica</i>	Antelope rat



**Appendix VI.** List of butterfly species recorded from the study area.

Family and Species	Common Name
<b>Papilionidae</b>	
<i>Pachliopta hector</i>	Crimson rose
<i>Pachliopta aristolochiae</i>	Common rose
<i>Papilio domoleus</i>	Lime butterfly
<i>Papilio polytes</i>	Common mormon
<i>Papilio polymnestor</i>	Blue mormon
<i>Graphium agamemnon</i>	Tailed jay
<i>Pathysa nomius</i>	Spot swordtail
<b>Pieridae</b>	
<i>Leptosia nina</i>	Psyche
<i>Delias eucharis</i>	Jezebel
<i>Belenois aurota</i>	Pioneer
<i>Cepora nerissa</i>	Common gull
<i>Ixias pyrene</i>	Yellow orange tip
<i>Hebomoia glaucippe</i>	Great orange tip
<i>Catopsilia pyranthe</i>	Mottled emigrant
<i>Catopsilia pomona</i>	Lemon emigrant
<i>Pareronia ceylanica</i>	Dark wanderer
<i>Colotis amata</i>	Small salmon arab
<b>Nymphalidae</b>	
<i>Eurema hecabe</i>	Common grass yellow
<i>Tirumala limniace</i>	Blue tiger
<i>Danaus chrysippus</i>	Plain tiger
<i>Danaus genutia</i>	Common tiger
<i>Euploea core</i>	Common crow
<i>Junonia lemonias</i>	Lemon pansy

<i>Junonia atlites</i>	Grey pansy
<i>Euthalia aconthea</i>	Baron
<i>Acraea violae</i>	Tawny costor
<i>Melanitis leda</i>	Common evening brown
<i>Orsotriaena medus</i>	Nigger
<i>Mycalesis perseus</i>	Common bushbrown
<i>Ypthima ceylonica</i>	White four-ring
<i>Elymnias hypermnestra</i>	Common palmfly
<b>Lycaenidae</b>	
<i>Spalgis epeus</i>	Apefly
<i>Curetis thetis</i>	Indian sunbeam
<i>Arhopala amantes</i>	Large oakblue
<i>Zesius chrysomallus</i>	Redspot
<i>Loxura atymnus</i>	Yamfly
<i>Junonia iphita</i>	Chocolate soldier
<i>Junonia almana</i>	Peacock pansy
<i>Hypolimnas bolina</i>	Great eggfly
<i>Hypolimnas misippus</i>	Danaid Eggfly
<i>Neptis hylas</i>	Common sailor
<i>Rathinda amor</i>	Monkey-puzzle
<i>Spindasis vulcanus</i>	Common Silverline
<i>Spindasis ictis</i>	Ceylon Silverline
<i>Jamides bochus</i>	Dark Cerulean
<i>Jamides celeno</i>	Common Cerulean
<i>Syntarucus plinius</i>	Zebra Blue
<i>Castalius rosimon</i>	Common Pierrot
<i>Talicauda nyseus</i>	Red pierrot
<b>Hesperiidae</b>	
<i>Potanthus pallida</i>	Indian Dart
<i>Telicota colon</i>	Pale Palmdart

**Appendix VII.** List of rescued species and numbers of rescued individuals of species from proposed extension to the quarry at Holcim limestone excavation site in Aruwakkalu. (E - Endemic species / VU - Vulnerable).

Family	Species	Common Name	Status	No. Rescued
<b>Amphibians</b>				
<b>Bufonidae</b>	<i>Duttaphrynus melanostictus</i>	Common house Toad		2
<b>Microhylidae</b>	<i>Kaloula taprobanica</i>	Common bull Frog		3
	<i>Uperodon systoma</i>	Balloon Frog		2
<b>Dicroglossidae</b>	<i>Fejervarya limnocharis</i>	Common paddy field Frog		8
<b>Reptiles</b>				
<b>Agamidae</b>	<i>Calotes caloes</i>	Green garden Lizard		2
	<i>Calotes versicolor</i>	Common garden Lizard		2
	<i>Otocryptis nigristigma</i>	Black spotted kangaroo Lizard	E	8
	<i>Sitana ponticeriana</i>	Fan-throat Lizard		14
<b>Chameleoniae</b>	<i>Chamaeleo zeylanicus</i>	Sri Lankan Chameleon		5
<b>Gekkonidae</b>	<i>Geckoella yakhuna</i>	Blotch bowfinger Gecko	E	8
	<i>Hemidactylus parvimaclatus</i>	Spotted house Gecko		15
	<i>Hemidactylus frenatus</i>	Common house Gecko		19

	<i>Hemidactylus leschenaultii</i>	Bark Gecko		4
	<i>Hemidactylus lankae</i>	Termite hill Gecko	E	11
<b>Scincidae</b>	<i>Eutropis carinata</i>	Common Skink		2
	<i>Lygosoma punctatus</i>	Dotted Skink		3
<b>Varanidae</b>	<i>Varanus bengalensis</i>	Land Monitor		1
<b>Colubridae</b>	<i>Ahaetulla pulverulenta</i>	Brown vine Snake		1
	<i>Boiga beddomei</i>	Beddom's cat Snake		1
	<i>Boiga forsteni</i>	Forsten's cat Snake		2
	<i>Chrysopelea taprobanica</i>	Striped flying Snake	E / VU	2
	<i>Dendrelaphis bifrenalis</i>	Boulenger's Bronze-back	E	1
	<i>Dendrelaphis tristis</i>	Common Bronze-back		1
	<i>Lycodon aulicus</i>	Wolf Snake		1
	<i>Lycodon osmanhilli</i>	Flowery wolf Snake	E	1
<b>Typhlopidae</b>	<i>Ramphotyphlops cf. braminus</i>	Common blind Snake		16
<b>Mammals</b>				
<b>Lorisidae</b>	<i>Loris lydekkerianus</i>	Grey slender Loris	E	1
<b>Muridae</b>	<i>Rattus rattus</i>	Common Rat		2
	<i>Tatera indica</i>	Antelope Rat		2
	<i>Vandeleuria oleracea</i>	Long-tailed tree Mouse		1
<b>Invertebrates</b>				
<b>Thelyphonidae</b>	<i>Thelyphonus sepiaris</i>	Whip-scorpion		13
<b>Theraphosidea</b>	<i>Poecilotheria fasciata</i>	Bird-eating Spider	E	27
<b>Chaerilidae</b>	<i>Chaerilus</i> sp.	Scorpions		9
<b>Chthoniidae</b>	<i>Afrochthonius</i> sp.	Pseudoscorpions		11
<b>Phrynichidae</b>	<i>Phrynichus</i> sp.	Tailless whipscorpion		6
	Other arthropods & Land snails rescued			19